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UNITED STATES DEPARTMENT OF AGRICULTURE
AGRICULTURAL RESEARCH ADMINISTRATION
BUREAU OF ENTOMOLOGY AND PLANT QUARANTINE

A REVIEW OF THE INSECTICIDAL USES OF ROTENONE AND ROTENOIDS FROM DERRIS, LONCHOCARPUS (CUBE AND TIMBO), TEPHROSIA, AND RELATED PLANTS

PART VIII: HYMENOPTERA

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1/ The manuscript of this publication was read in the following research divisions of the Bureau and helpful suggestions were contributed: Fruit Insect Investigations, Truck Crop and Garden Insect Investigations, Cotton Insect Investigations, Insects Affecting Man and Animals, Insect Identification, Control Investigations, Cereal and Forage Insect Investigations, and Bee Culture. The reviewers in these divisions were, respectively, B. A. Porter, W. H. White, U. C. Loftin, H. H. Stage, C. F. W. Muesebeck, H. H. Richardson et al., C. M. Packard, and Jas. I. Hambleton.

INTRODUCTION

This is the eighth in a series of papers designed to review all available information on the insecticidal uses of rotenone and the rotenoids. Parts I-VII have reviewed tests with derris, cube, timbo, Tephrosia, Mundulea, and their constituents on members of the Collembola, Orthoptera, Dermaptera, Odonata, Isoptera, Corrodentia, Mallophaga, Thysanoptera, Homoptera, Hemiptera, Anoplura, Coleoptera, and Lepidoptera. Apparently no tests with the rotenone plants on Thysanura, Ephemeroptera, or Plecoptera have been recorded. Part VIII, the present paper, reviews the tests and recommendations for use on Hymenoptera.

HYMENOPTERA

Apidae

Apis mellifera L., the honeybee

In 1919 McIndoo, Sievers, and Abbott (86) extracted fine derris powder successively with five solvents--petroleum ether, ether, chloroform, alcohol, and water, in five different sequences. Water used as the primary solvent extracted 10.8 percent of the material. The extracts and the marcs were added to honey and were fed to honeybees. The extracts were dissolved in alcohol (0.4 gm. in 10 cc. of 95-percent alcohol), and 0.25 cc. of this solution was mixed with 5 cc. of honey. The water extract had no effect on the bees tested and the powder exhausted with water killed 94 percent of the bees within 48 hours. All the other extracts were almost equally toxic to honeybees. The powders exhausted with ether, chloroform, and alcohol (1/8 gm. of powder mixed with 5 cc. of honey) had very little effect on bees.

In 1928 Ginsburg (36) reported that a suspension of derris (1:400) killed 100 percent of the honeybees after 24 hours, and a suspension of cube root (1:200) killed 100 percent after 48 hours. These suspensions were mixed with honey and were fed to the bees.

Campbell (16) in 1932 referred to the work of Ginsburg, who "compared the susceptibility of aphids and honeybees to rotenone suspensions without spreader. A dilution of 1:160,000 killed 83.2 percent of the aphids and one of 1:5,000 killed 74.5 percent of the bees in 24 hours. Honeybees are evidently more resistant to rotenone suspensions than are aphids."

In 1932 Ginsburg and Schmitt (37) compared the contact insecticidal action of rotenone and the pyrethrins. Honeybees were sprayed with aqueous suspensions of rotenone and derris extract, and pyrethrum extract, obtained by adding acetone solutions of these to water without a spreader. Rotenone at 1:2,500 and derris root at 1:400 (equivalent to 1 part of rotenone to 13,200 parts of water) killed 100 percent of the honeybees in 24 hours. Pyrethrum at 1:400 (equivalent to 1 part of pyrethrins to 44,000 parts of water) killed 89.3 percent of the bees in the same time.

Gerard (33) in 1935 called attention to the poisoning of honeybees caused by dusting blooming raspberries with derris dust for the control of the raspberry beetle in 1934 in England. A microscopic examination of the dead and dying bees revealed the presence of a fine brownish dust. The entrances to the tracheae were thickly covered with the powder, and Gerard suggested that the flying bees had died from actual suffocation due to the tracheae becoming blocked with the powder, whereas the dead brood had been poisoned by being fed pollen in which this powder had been mixed by the bees.

In 1935 Tischler (114) studied the mechanism by which derris kills insects. Tests made with insects such as bees led to the conclusion that derris inhibits the utilization of oxygen by the tissues and that its detrimental effects are general rather than specific to any organ. Experiments in which bees were exposed to a stream of air passed over derris powder and derris extracts, and to the build-up vapors of these derris materials in a container confirmed the findings of other investigators that derris does not emit a toxic vapor.

In 1935, the United States Department of Agriculture, Bureau of Entomology and Plant Quarantine (118), reported the results of laboratory tests on bees at Somerset, Md. Under laboratory conditions derris, cube, and pyrethrum were extremely toxic to bees, both as stomach poisons and as contact sprays.

DeBussy et al. (14) in 1936 reported that this species is sensitive to derris dust or spray. No reports of damage to bee culture in Holland have been received.

In 1936 Hundertmark (48) tested the rotenone and derris proprietary products Derosil, Derrothan I, and Derrothan II on bees. All were toxic. The dusts were applied in the laboratory at the rate of 50 kg. per hectare (44.5 lbs. per acre).

In 1936 Van der Laan (78) found that bees are sensitive to derris, especially to dusts. In 1937 Bottcher (7) discussed the killing of bees by insecticides, including derris.

Filmer (29) reported in 1937 that a dust containing 0.75 percent of rotenone, 20 to 25 percent of sulfur, and about 15 percent of copper, applied by airplane to lima-bean fields on the evening of July 19 near Findley, N. J., was believed to be responsible for many dead bees found nearby. The fact that nurse bees, as well as field bees, had been poisoned suggested that the rotenone dust has poisoned the nectar. To check this theory, sugar solutions containing varying quantitites of rotenone dusts were fed to colonies of bees. Dilutions of dusts containing 4 percent of rotenone were added to dilute sugar sirup to make up dilutions containing the following amounts of rotenone: 1:2,500 (= 0.4 percent); 1:1,250; 1:625; 1:317. These dilutions when fed to colonies of bees were all toxic with the exception of the 1:2,500 dilution. The colony fed this solution showed no signs of poisoning and built up normally. The other colonies showed symptoms of poisoning the day following the feeding of the sirup, and in all colonies practically all the bees were killed within 72 hours. The general symptoms were similar to those due

to arsenical poisoning, with bees crawling from the hives, the abdomens of many being greatly distended. To check the contact action of rotenone dusts several batches of bees were dusted directly with an 0.75-percent dust and were then placed in clean cages. Other batches of bees were placed in cages, the floors of which had been dusted lightly with 0.75 percent-rotenone dust. A complete kill was obtained in 24 hours.

According to Stellwaag (112) in 1937, derris is both a contact and a stomach poison to bees.

Böttcher (8) in 1939 recorded the results of tests of derris and rotenone upon bees. Rotenone had a lethal effect on bees as a stomach and a contact poison, but was ineffective by inhalation. The toxic effect was influenced but little by the temperature. The minimum lethal dose of pure rotenone in a 0.2-percent concentration was 0.5 to 11 micrograms. The median lethal dose was about 3 micrograms. From 0.6 to 1.7 micrograms gave mortalities of 25 to 33.3 percent at a temperature of 20°-34.5° C. Derris extracts (0.5 and 5.6 micrograms of rotenone) were more effective than the same amount of pure rotenone. The median lethal dose was about 2.2 micrograms. From 25 to 33.3 percent of the bees treated with about 1.1 micrograms of rotenone died within 3 days. Concentrations up to 0.02 percent of rotenone in sprays and to 1.75 percent in dusts did not seriously injure either the workers or their brood, and the injuries to bees collecting pollen and honey were insignificant. Even when the concentration was 10 times as great, relatively few bees succumbed to the treatment. Large-scale experiments in fields frequented by bees confirmed these results.

In 1939 Downes (20) reported that a colony of honeybees under the shingles of a house was destroyed with a dust of derris powder (4 percent rotenone).

Braconidae

DeBussy et al. (14) in 1936 reported that full-grown braconids in tobacco seed are very sensitive to derris dust.

Cephidae

Janus integer (Nort.), the currant stem girdler

In 1938 the New York County Agents Training School (93) stated that emergence of the currant stem girdler in Chautauqua County, N. Y., extended over the period May 5 to June 10, with the most activity from May 20 to 28. Sprays containing nicotine, derris, or pyrethrum were not effective in limited tests.

Diprionidae

Diprion pini (L.)

In 1936 DeBussy et al. (14) reported that larvae of (Lophyrus) Diprion pini were sensitive to a dust containing 0.25 percent of rotenone. This insect on trees was controlled by this dust applied with a motor-driven duster.

Houtzagers (47) in 1936 discussed control measures, stating that there was only one practical method of control for the pine wasp, namely, dusting with derris powder containing at least 0.5 percent of rotenone, as soon as a part of the forest is infested. The derris powder should be applied at the rate of 20 to 25 kg. per hectare. The infestation usually begins on the sunny exterior portions of the forest, and the beginning of the infestation can be readily observed. If treated at this time, it is sufficient to apply the derris dust to a strip 15 to 20 meters wide. By operating in this way dusting an area of 2.5 hectares is sufficient to protect a forest having an area of 10 hectares, thus reducing the per-hectare cost of protecting the whole forest to 20 guilders per hectare. If the infestation has proceeded too far, the cost of the dusting is excessive and the only thing to do is to let the infestation run its course.

Klinger (73, 74) in 1936 reported that rotenone-talc dust (0.15 mg. of rotenone per 415 sq. cm.) killed none of the fourth instars and a rotenone spray (0.18 mg. per 500 sq. cm.) killed only 5 percent in 8 days.

Van der Laan (78) in 1936 reported control with derris dust applied by a power duster.

An anonymous writer (3) in 1937 wrote that in the Netherlands dusting tests with a 0.5-percent concentration of rotenone against this species produced good results.

In 1938 the Koloniael Instituut of Amsterdam (77) in the Netherlands reported that one of the principal uses of derris dust (0.5 to 0.75 percent rotenone) during 1937 was for combating this species.

Spoon et al. (109) in 1937 compared the insecticidal value of derris powder and of Lonchocarpus powder, both containing equally high amounts of rotenone and other extract. Against the larvae the derris-diatomaceous earth (0.5 percent rotenone) dust was about 1½ times as effective as the Lonchocarpus dust.

Diprion simile (Htg.), the introduced pine sawfly

McDaniel (84) in 1939 recommended a dust containing 0.75 percent of rotenone, although about 72 hours was necessary to obtain any indication of kill. Cryolite and calcium arsenate dusts were more effective.

Diprion hercyniae (Htg.), the European spruce sawfly

MacAloney (82) in 1936 reported, under the name Diprion polytomum, that derris showed promise, and Potts (101, 102) in the same year reported that derris extract, 0.5 pound to 100 gallons of water (containing 0.5 percent linseed oil), and derris powder (4 percent rotenone), 2 pounds to 100 gallons of water (containing 0.5 percent linseed oil), were very effective. Final observations on sprayed plots showed excellent control by derris extract, derris, lead arsenate, calcium arsenate, and lime-sulfur. Poor control resulted from nicotine in any form, pyrethrum, bordeaux mixture, and phenothiazine.

Neodiprion lecontei (Fitch), the red-headed pine sawfly

Hamilton (41) in 1938 reported that larvae on white pine trees were controlled 100 percent by a spray of derris or cube powder (4 percent rotenone) at 4 pounds per 100 gallons of water plus 4 pounds of rosin-residue emulsion. The spray acts as a contact poison. The effective period was 4 to 6 days and full-grown larvae were fairly easily killed.

McDaniel (84) in 1939 recommended a dust containing 0.75 percent of rotenone, although about 72 hours was necessary to obtain any indication of kill. Cryolite and calcium arsenate dusts were more effective.

Neodiprion pinetum (Nort.), the white-pine sawfly

See McDaniel (84) under N. lecontei (Fitch).

Neodiprion sp.

Potts (103) in 1937 reported that derris (4 percent rotenone) at 1:500 and 1:1,000 was very effective both as a stomach poison and as a contact spray against the larvae in laboratory tests.

Formicidae

Anoplolepis longipes (Jerd.)

According to Van der Vecht (119) in 1936, some small-scale tests against the "gramange" ant (Plagiolepis) Anoplolepis longipes gave unsatisfactory results. If the treatment is to be done properly, so much powder must be used that the control would not be profitable in most cases.

Camponotus herculeanus (L.)

In 1933 Lindblom (80) reported that when derris powder was strewn around in the room or paths where these ants were prevalent, or was blown into cracks or holes in the walls, complete kills were obtained.

Camponotus sp.

In 1934 Lindblom (81) wrote that when blown into their nests in hollow trees, derris powder was fairly satisfactory.

Downes (20) in 1939 reported remarkable success with derris powder containing 4 percent of rotenone. No matter where the nest was situated or how extensive the infestation, if the powder could be placed where the ants must walk through it and thus get some of it on their bodies, the colony could be exterminated rapidly.

Dolichoderus (Hypoclinea) bidens (L.)

Reijne (104) in 1919 reported that of various sprays used, carbolic acid and Phytophiline gave the best results, but the high cost of the latter precluded its use. Nekoe water (probably an infusion of cube root) was useless. [According to some reports the proprietary product Phytophiline contains rotenone and rotenoids.]

Dolichoderus bituberculatus (Mayr)

According to Van der Vecht (119) in 1936, the black cacao ant is very sensitive to derris. Dusting with derris powder (rotenone 0.5 percent) or spraying with suspensions containing rotenone at 1:10,000 is usually effective.

Formica rufa L.

Lindblom (80) in 1933 reported results obtained with derris against mound-building, or fallow, ants. Derris was spread in a ring around the anthill, so that the insects had to come in contact with it on entering or leaving the mound. The ants at first hesitated before crossing the strip of powder but later did so freely. Eight or ten minutes after having been in contact with the derris, the ants began to lose control of their movements and later became paralyzed and died. The following day an area of 8 to 10 meters from the mound was covered with dead or half-dead ants. At intervals of a few days more derris was strewn around, until 1.5 kg. had been used. Four weeks later the mound was opened, and it was found that every insect had been destroyed.

Iridomyrmex humilis Mayr, the Argentine ant

J. E. Eckert, (26a) in 1940 reported that he had found derris powder, lightly sprinkled where the ants enter, very effective in keeping these ants out of the honey house and away from colonies of bees in the apiary and from entering his own home. Since, after 4 or 5 days, the ants seemed to be about as numerous as before, he concluded that the material must act more as a repellent than as a definite poison.

Myrmica rubra (L.)

In 1935 Van der Scheer (106) reported that red ants were controlled by spraying with rotenone emulsion 1:80,000. Rotenone was dissolved in benzene and this was emulsified in water with Igepon T.

Red ants were used by Spoon and Van der Laan (108) in 1935 in evaluating derris dusts and sprays. It was concluded that in rating derris products first consideration should be given to rotenone content.

DeBussy et al. (14) in 1936 reported that these ants are sensitive to derris dust (rotenone 1 percent) and derris spray (rotenone 1:5,000), but that the effect does not appear immediately. An entire city garden in Amsterdam was dusted with derris powder containing 7 percent of rotenone and 17 percent of ether extract. No ants could be found after 10 days.

Van der Laan (78) in 1936 reported these ants as sensitive to derris.

Spoon et al. (109) in 1937 stated that Derris and Lonchocarpus powders were each diluted with diatomaceous earth to rotenone contents of 0.5, 0.75, and 1.0 percent and tested against this species. Derris dust was twice as effective as Lonchocarpus dust of the same content of rotenone and ether extract.

The Mysore (India) Agricultural Department (89) in 1938 reported that derris powder (7 percent rotenone and 22 percent ether extract) was effective against red ants.

Oecophylla smaragdina (F.)

In 1936 Van der Vecht (119) stated that, although spraying and dusting the nests of the "nangrang" ant with derris powder plus talc (rotenone 1-1/3 percent) and derris powder in water (rotenone 1:2,000) killed a great many ants, it did not seem possible to eradicate the ants completely in this way.

Prenolepis sp.

The British Guiana Department of Agriculture (13) in 1934 reported that an aqueous extract of haiari gave excellent results against an undetermined species of ant, probably Prenolepis, infesting coffee trees.

Solenopsis geminata (F.), the fire ant

Travis (116) in 1939 reported the results of tests of soil treatments for the control of the fire ant. Commercial derris powder was applied in sufficient quantities to cover the colony mound with a thick coating of dust. At the time of application, the colony was stirred with a stick to expose as many ants as possible to the powder. Three hours after treatment many partially paralyzed ants were seen, and large numbers of dead ants were carried from these colonies during the following week. One week after treatment 20 percent of the colonies showed no activity, but 3 months later all were active and appeared normal.

Solenopsis sp.

The Department of Agriculture of British Guiana (13) in 1934 published results of tests of cold water, hot water, and carbon tetrachloride extracts of the bark, stems, and leaves of fresh young shoots of haiari against the red stinging ants. None of the extracts had any effect on them.

Tetramorium caespitum (L.), the pavement ant

Walker and Anderson (121) in 1937 reported that in 1935 a derris spray applied around the base of infested eggplants at Norfolk, Va., was not effective against the pavement ant. In 1936 derris fumigant powder, containing 5 percent of rotenone, killed a few of the ants and appeared to have a slight temporary repellent action, but the ants soon returned and eventually killed two of the plants. Finely ground derris powder was used undiluted as a dust containing 5 percent of rotenone, and diluted with both sulfur and talc to make dusts each containing 1 percent of rotenone, and with finely ground tobacco to make a dust containing 0.75 percent of rotenone. None of these materials had any noticeable effect on either the ants or the plants, the ants continuing to feed on the eggplants in the presence of derris.

Formicidae (unidentified species)

Wood (123) in 1912 reported that a preparation made by adding 2 pounds of crushed fresh derris root to 2 imperial gallons of boiling water, soaking it for a few hours and then diluting it by adding 1 quart of this stock solution to 2 gallons of water, repelled ants from a bed of germinating celery without damaging the plants.

Gilmer (34) in 1923 wrote that derris is fully the equal of pyrethrum as a check against ants.

Lindblom (81) in 1934 published directions for destroying red, yellow, and black American lawn ants in Sweden by strewing pure derris powder in a narrow circle around the anthill or in places where the ants will come in contact with the powder.

Stanco, Inc., in 1934 first advertised Flit powder, a pyrethrum product with 1 percent of "rotenone extractive". According to a label received in 1937 from the manufacturer, Flit Powder contains 94 percent of pyrethrum flowers, 1 percent "extract tubatoxin", and 5 percent of inert ingredients. It is recommended for control of ants.

Miles and Miles (88) in 1935 wrote that, for the control of ants in glasshouses, derris dust may be blown into crevices and cracks.

DeBussy et al. (14) in 1936 reported that ants are sensitive to derris dust (rotenone 1 percent) and derris spray (rotenone 1:5,000), but that the effect does not appear immediately. An entire city garden in Amsterdam was dusted with derris powder containing 7 percent of rotenone and 17 percent of ether extract. No ants could be found after 10 days.

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The Idaho Agricultural Experiment (53) in 1936 reported results of preliminary tests made with a cube-kaolin dust mixture containing 0.02 percent of rotenone. This mixture, applied in the center and over the top of an anthill, killed most of the colony, and a second application 2 weeks later usually served to exterminate it. Occasional light dustings of the mixture around shrubbery or ornamentals or at places where the insects entered the buildings effectively controlled ants.

In 1936 the Koloniaal Instituut of Amsterdam (75) reported that ants can be destroyed with the help of derris.

Van der Laan (78) in 1936 stated that ants are rather sensitive to derris.

McDaniel (83) in 1936 published directions for ant control in houses and on lawns. After discussing sprays, fumigants, and poison baits he stated that poison dusts, such as borax, pyrethrum, derris, or some of the fluorine compounds, should be distributed where the ants will walk through it, and the barrier kept there as long as ants are present. Poison dusts are satisfactory only when dry. Neither borax, nor pyrethrum, nor derris are poisonous to higher animals.

Schoevers (107) in 1936 wrote a general account of derris in which mention was made of its use to control ants.

In 1936 Van der Vecht (119) stated that in the Netherland Indies only a few ants were recorded as injurious. Although ants are very sensitive to derris, it is doubtful whether any use of derris on a larger scale would be practicable. Ants which, for example, attend injurious plant lice on cultivated plants can be killed by dusting or spraying; but unless the nests are eradicated, success is short-lived. The use of derris in baits has shown some promise. Derris has demonstrated some use as an ant repellent; floors dusted with it were avoided by these insects, but the powder must be regularly renewed.

Dietz (19) in 1938 advised the housewife on control of ants. If a poisonous material is undesirable, use ground derris powder or, in an emergency, use any one of the many common fly sprays once or twice a day.

Haude in 1939, in advertising literature published by John Powell & Co., New York, N. Y., recommended dusting around the anthills with cube or derris (0.75 percent rotenone).

Hackley (39) at the meeting of the California Pest Control Association held at Oakland, Calif., in 1939, stated that some brands of derris powder are very effective ant repellents until destroyed by light.

C. B. Dibble in a "Bug Flash" in 1940 recommended derris or cube powder as a barrier against ants in cupboards.

Hackley (40) in 1941 wrote that some derris powders effectively repel ants for several days. This repellent quality does not exist equally in all brands or types; some that were tried were lacking in this respect. The one that was most effective was very pungent and so irritating to the nose and throat that care was needed to avoid the unpleasant effect. It seems likely that the value of the powder lies in this irritating quality.

Tenthredinidae

Athalia colibri (Christ.)

DeBussy et al. (14) in 1936 reported that larvae were successfully controlled with a derris dusting mixture.

Trappmann and Nitsche (115) in 1935 reported on the action of rotenone and pyrethrins on various insects. A pyrethrum-talc dust containing 0.15 percent of pyrethrins, a rotenone-talc dust containing 0.15 percent of rotenone, a spray containing 0.15 percent of pyrethrins in 50 percent of Turkey-red oil, and a spray containing 0.15 percent of rotenone in the Turkey-red oil were tested against a variety of insects. The dusting bell jar described by Lang and Melts (Nachrichtenbl. f. den Deut. Pflanzenschutzdienst 10(9):75-76) was used for the tests with the dusts, and the balance described by the authors (Ibid. 14(5):51-52.) for spray materials was used for the spray tests. In every case the dosage was regulated to give a deposit of 0.18 mg. of pyrethrins or rotenone per sq. cm. The tests were made with the insects in glass dishes 5.5 centimeters high and 15 centimeters in diameter, 10 insects in each dish. Rotenone spray killed only 10 percent of the larvae of this species after 8 days.

Riggert (105) in 1939 reported that three dusts containing both pyrethrum and derris killed 99.5, 95.5, and 65.9 percent, respectively, of the larvae within 24 hours in tests made in 1936; whereas two dusts, containing pyrethrum only, killed 4.5 and 24.1 percent, respectively.

Caliroa aethiops (F.), the rose sawfly

According to the (Tokyo) Institute of Physical and Chemical Research (55) in 1927, Nicotine, 1 pound in 40 imperial gallons of water, completely exterminated larvae of the rose sawfly.

Gorham (38) in 1928 reported on the European rose sawfly in New Brunswick, Canada. It was found that, like other sawfly larvae, these were very susceptible to the toxic action of derris dust and that they dropped in a helpless condition within 2 hours after application. No objectionable stains were left on the foliage or blooms.

In 1938 Parks and Pierstorff (97) of the Ohio Agricultural Extension Service, recommended spraying with derris powder (4 percent rotenone) at the rate of 3 pounds in 100 gallons of water for the control of the rose slug on roses.

Haude in advertising literature published by John Powell & Co., New York, N. Y., in 1939 recommended cube or derris dust (0.75 percent rotenone) or spray (4 pounds of powder of 4 percent rotenone content per 100 gallons).

Caliroa cerasi (L.), the pear slug

In 1932 Andries (5) reported derrisol as effective against the pear slug.

DeBussy et al. (14) in 1936 reported that this insect is sensitive to derris dust.

According to an anonymous writer (2), the University of Bristol Research Station at Long Ashton, England, in 1937 demonstrated control by the use of combined washes containing white-oil emulsion and rotenone-containing substances.

The Colorado Experiment Station (17) in 1937 stated that derris or cube powder containing 3 percent of rotenone, at the rate of 4 pounds to 100 gallons of water, gave controls equal to those effected by lead arsenate. Rotenone dusts were also used on this slug.

Kearns and Marsh (60) in 1937 recommended derris spray for control and reported that the second brood is best controlled by the application in mid-July of a spray containing 6 ounces of nicotine and 1/2 pound of wetter to 100 imperial gallons of water, or that 1.5 pounds of derris or barbasco root, containing not less than 1.5 percent of crystalline rotenone, may be substituted for the nicotine.

Evans (27) in 1938 reported that the pear slug (Caliroa cerasi (L.)) in Tasmania is best controlled on fruit trees with lead arsenate but that lead arsenate should not be used on plum or cherry trees when the fruit is ripe or almost ready for picking; instead, any contact insecticide, such as nicotine sulfate or derris, should be applied either as a spray or as a dust. Hawthorn hedges surrounding gardens should be given two applications of a derris dust, which acts as both a stomach and a contact poison. The first application should be made during the first fortnight in December and the second during the first fortnight in February. The second application, which is intended for larvae of the second generation, is the most important.

Hamilton (41) in 1938 reported that pear slugs on pear trees were controlled 100 percent by a spray of derris or cube powder (4 percent rotenone) at 4 pounds per 100 gallons of water plus 4 pounds of rosin-residue emulsion. The spray acts as a contact poison and as a repellent. The effective period is 6 days.

According to the New Jersey Agricultural Experiment Station (91) in 1938, derris or cube powder in water to which rosin-residue emulsion had been added was shown to be effective against sawfly or pear slug larvae.

Emphytus albicinctus Mats. var. meridionalis Takeuchi

Oishi (96) in 1934 reported that the larvae can be killed by a derris spray.

Fenusa pulsilla (Lep.) (Syn., F. pumila)

Turner (117) in 1932 reported that cube extract in 1-percent oil emulsified with powdered milk (cube extract 1:25,000) killed 74 percent of the larvae in mines; the check oil killed 3 percent.

Hoplocampa flava (L.)

Kearns, Marsh, and Martin (61) in 1935 reported trials carried out the previous year at Long Ashton, England, with combined sprays for the control of "red spider, caterpillar, and plum sawfly" on plums. At Pinvin trials were carried out on trees of the Czar variety. Double spraying was employed, and two types of spray were tested in the second application. For the first application, on May 11, 7 days after petal fall, a spray containing lead arsenate and nicotine was used. The second application was made on May 29, when half the trees sprayed on May 11 received an oil and lead arsenate spray. The remaining half of these trees were sprayed on May 29 with a derris-lead arsenate spray of the following composition: Ground derris root (2 percent crystalline rotenone) 2 pounds, lead arsenate powder (300-mesh) 4 pounds, Lethalate wetting preparation 8 ounces, and water 100 gallons. The control of the plum sawfly was in no case satisfactory, as the first spray was applied before oviposition was completed, whereas the second spray did not provide any material control of wandering sawfly larvae.

The University of Bristol Agricultural and Horticultural Research Station at Long Ashton, England (11), in 1936 reported that carefully timed applications of nicotine and arsenate sprays did not provide a satisfactory control of the plum sawfly. Derris was the most satisfactory spray.

Jancke and Maercks (57) in 1936 reported the following results with pure rotenone: On blooming twigs, a 0.75-percent solution killed 51 percent of the eggs of the plum sawfly and a 0.5-percent solution killed 35 percent; on twigs that had ceased blooming, a 0.5-percent solution killed 58 percent of the eggs and a 0.75-percent solution killed 73 percent.

Leib (79) in 1936 reported the results of tests of a commercial derris product applied as a spray at 0.4-percent concentration against the plum sawfly; 81 to 95 percent of the fruit treated 3 times at 4- to 5-day intervals with this spray was sound, without holes.

Petherbridge and Thomas (98) in 1936 reported on the control of the plum sawfly in England with derris. Two sprayings (derris 0.8 pound, spreader 3 pints, or sulfonated lorol 1/3 pound, water 40 imperial gallons) gave better results than did spraying with nicotine sulfate (10 ounces) plus lead arsenate (1 pound) to 40 imperial gallons. Only 5.2 percent of the damsons on the trees sprayed with derris were injured, whereas the unsprayed trees showed 16.7 percent damage. One dusting

with a derris dust (0.2 percent rotenone) was not satisfactory. In the case of a bad attack they recommended spraying twice with derris, 0.8 pound plus 5 ounces of a spreader in 40 imperial gallons, when the cots (receptacles) are beginning to split, and also a week later.

Steer (110) in 1936 reported that the use of derris against the plum sawfly apparently was not a marked success, but that observations made in 1934 suggested that it might with advantage be used in a dry form against migrating larvae when the first signs of secondary attack are observed.

Kearns and Marsh (60) in 1937 recommended derris or derris extract as a spray for control of the plum sawfly in England. The spray should contain not less than 0.004 percent of crystalline rotenone. The trees should be sprayed about May 10-20 and again 7 days later. Barbasco or any other rotenone-containing material may be used as a substitute for derris, provided it is suitable for use with a white-oil emulsion.

Kearns, Marsh, and Martin (63) in 1937 reported that a refined petroleum oil proved more effective than a water-soluble spreader as a supplement for rotenone-containing sprays applied for the control of the plum sawfly.

Petherbridge and Thomas (99) in 1937 recommended the following spray for the control of the plum sawfly when the fruit-tree red spider or the plum thrips is troublesome: Mineral-oil emulsion 3-1/5 pints, derris 12 ounces, water 40 imperial gallons. Used against the plum sawfly, derris with the oil was better than derris with sulfonated lorol. The fruit-tree red spider and the thrips were controlled only by the derris-oil spray.

Jary and Austin (58) in 1938 reported that heavy attacks by the plum sawfly in Kent, England, were controlled commercially by applications of derris and derris-petroleum-oil sprays.

Kearns and Martin (65) in 1938 recommended a spray containing 0.67 gallon of actual oil and 1 pound of derris or Lonchocarpus ground root (rotenone 4 percent) in 100 imperial gallons of water for the control of the plum sawfly. Oil emulsion gave better results than a water-soluble wetter, but if for any reason the latter is preferred 0.5 pound of Agral-2, or Lethalate Wetting Preparation, or sulfonated lorol, per 100 gallons may be used. One drenching application made just before the hatching of most of the eggs controls not only the sawfly but also the red spider. An extract of Lonchocarpus nicou gave a more potent combined spray than did the powdered root.

Steer and Hassan (111) in 1938 reported that in field spraying trials on the control of the plum sawfly on Czar plums, one spraying with derris gave substantially as good a result as did two sprayings. Derris at 0.2 percent (equivalent to a crystalline rotenone content of 0.004 percent), in conjunction with soap, gave an adequate measure of control if applied at any time during the 7 to 10 days following petal fall. An unusually low concentration of derris (equivalent to about 0.002 percent crystalline rotenone) gave very promising results. Nicotine at 0.05 percent and lead arsenate paste at 0.4 percent were each ineffective, whereas a preparation of thiodiphenylamine at 0.1 percent

was only partially successful. The derris powder contained 10.4 percent of ether extractives and 2.14 percent of rotenone. The soap was prepared by dissolving 3 ounces of caustic soda in 50 gallons of water and then adding a pint of commercial brown oleine. On each occasion the spraying was followed by rain.

Hoplocampa minuta (Christ.)

Ahlberg (4) in 1934 reported spraying experiments to kill the eggs of this plum sawfly. The sprays tested included pyrethrum and derris preparations, and the trees were sprayed immediately before as well as during and after blooming. These sprays have given no results up to now.

The Wageningen Plantenziektenkundige Dienst (120) in 1934 reported that rotenone, 1:10,000 with 0.2 percent of Agral I, was sprayed on plum to control this species. The results could not be ascertained because the insects were repelled. Rotenone 1:5,000 with 0.1 percent of Agral I, was sprayed on plum on May 3 and May 16, 1933, with satisfactory results.

DeBussy et al. (14) in 1936 reported that sprays of derris having a rotenone concentration of 1:5,000, 1:8,000, and 1:10,000, plus a spreader, applied immediately after the appearance of the eggs, gave good control of this species. A concentration of rotenone 1:13,000 proved too dilute to be effective.

In 1936 Van der Laan (78) reported that this species may be controlled with derris dust.

Hoplocampa pyricola Roh.

Yago (124) in 1933 wrote that this species, formerly abundant in pear orchards in Shidzuoka, Japan, had become scarce, probably owing to the use of insecticides, including derris.

Hoplocampa testudinea (Klug)

Austin, Jary, and Martin (6) in 1932 reported that a Polvo-soap solution was prepared by the addition of 1/3 gallon of brown commercial oleic acid to 100 gallons of water containing 1 pound of flake caustic soda. Polvo at the rate of 2-1/2 pounds per 100 gallons was stirred into a smooth past with a little of the soap solution and then added to the bulk of the solution in the spray tank. This gave a control of the apple fruit sawfly similar to that given by nicotine at 8 ounces per 100 imperial gallons. Katakilla (5 pounds per 100 imperial gallons of water) gave equally good control.

The Agricultural and Horticultural Research Station of the University of Bristol, England (10), in 1933 stated that derris emulsion, ground derris root in a soap suspension, pyrethrum emulsion, and colloidal lead arsenate were tested against the apple sawfly, the derris emulsion giving results equal to the nicotine spray which, when applied 5 to 8 days after petal fall, had given the highest control.

The East Malling Research Station (23), Kent, England, in 1933 reported that a derris dust of known composition was applied at night to apple trees infested with the apple fruit sawfly.

> The dust was applied by means of a hand duster on June 22 at 8 p.m. White sheets were placed under the dusted trees, while other sheets were placed under adjoining trees, which were left as controls. The weather proved to be bitterly cold for the time of the year (the temperature registered only 1° above freezing soon after midnight), but in spite of this a number of larvae came out, as usual, after dusk. The observations were contined each night, and after 4 nights more than 100 larvae were removed from the white sheets under each dusted tree, while an average of 23 larvae were collected from each of the sheets under the control trees.

Kearns, Marsh, and Pearce (64) in 1933 reported that derris spray gave a good measure of control of the apple sawfly. Commercial experience with derris as a means of controlling apple pests in England is limited and the results have been variable. The indifferent results are probably due to the use of too low a concentration of the toxic principle (rotenone). Derris is used mainly in two forms for the preparation of sprays: (a) Finely ground derris root added to a weak soap solution, and (b) an oil emulsion consisting of a derris extract in a mineral or vegetable oil. The duration of effective toxicity after application of some preparations may be several days, but critical data on this point are not available for apple pests. Derris dusts have not been used to any extent on apples.

Kearns and Swarbrick (68) in 1933 reported further observations on the control of the apple sawfly. Among the sprays tested were the following: (1) derris-soap solution: 2.5 pounds of finely ground derris root, 10 pounds of soft soap, 100 imperial gallons of water (rotenone 0.004 percent, which was sufficient to kill the young larvae provided it came in contact with them). This spray possessed good spreading properties. (2) Derris emulsion: A proprietary spray consisting of a derris extract in a rape-oil emulsion and applied at a concentration representing approximately 1.0 percent of the rape oil and an undetermined content of rotenone. The emulsion wetted the fruitlets thoroughly. These sprays were applied 7 days after petal fall. Trees sprayed with the derris emulsion had 9.2 percent of infested fruits and those sprayed with derris-soap had 15.1 percent, as compared with 41.0 percent in the untreated check. The best control (2.7 percent of infested fruits) was given by nicotine (8 fluid ounces of 98 percent nicotine, 2.5 pounds of Agral I as activator and spreader, 100 imperial gallons of water) applied 6 days after petal fall. Derris-soap did not give good results because it killed only exposed larvae and not those in burrows. The derris emulsion reduced the infestation to 9.2 percent and possibly owed its increased efficacy, as compared with the derris soap, mainly to the ease with which it penetrated the larval burrow because of the presence of the oil.

Kearns and Walton (70) in 1933 reported tests with derris spray (2.5 or 5 pounds of derris powder containing 1.72 percent of rotenone, and 10 pounds of spraying soap per 100 imperial gallons) and derris emulsion (derris extract in rape oil). The proprietary derris emulsion gave a good control of the apple sawfly, whereas the derris in soap suspension gave a poor control.

The East Malling Research Station (24) of Kent, England, in 1934 stated that derris in both wet and dry form was tried against the apple sawfly. Derris dust prevents oviposition by this insect.

Hey, Moore, and Steer (44) in 1934 made the following recommendation for the control of the apple sawfly:

> The object of a petal-fall application for sawfly is to kill the eggs and so to prevent infestation of the fruits. If, for any reason, this spray is omitted, some loss can still be avoided. Examine the trees about a fortnight after petal fall and, if tunnels under the skin or holes in the sides of the fruitlets are seen, apply a derris dust immediately to protect the remaining uninjured fruits. If the dust is washed off by rain within 10 days of application, then dust again.

Hey and Steer (45, 46) in 1934 reported experiments undertaken to determine the relative value of control measures against the apple sawfly adults by means of derris; against the eggs by means of nicotine; and against the young larvae by means of (a) petal-fall applications of derris, barium silicofluoride, and lead arsenate, and (b) post-petal-fall applications of derris, barium silicofluoride, lead arsenate, and nicotine; and against the migrating larvae by means of derris and nicotine. The derris contained 2.71 percent of crude rotenone and was used at the rate of 2 pounds per 100 imperial gallons plus 8 pounds of soft soap. The derris dust consisted of 10 percent of derris and 90 percent of china clay. The report states:

> When used primarily against the larvae, nicotine and derris were of approximately equal value at the concentrations used. In addition to killing those larvae with which it comes into contact, nicotine probably kills the unhatched eggs remaining at the time of spraying. On the other hand, derris is probably toxic only to the larvae, though its residual contact properties give it an advantage over nicotine which compensates for its presumed lack of ovicidal effect.
>
> As a dust the scope of derris appears to be restricted to its uses (a) as a means of preventing oviposition by killing the adults and (b) as a means of arresting secondary infestation by migrating larvae. For the latter purpose derris-soap and nicotine-soap sprays also seem effective.

Nicotine (95-98 percent) was used at the rate of 8 ounces per 100 imperial gallons plus 8 pounds of soft soap.

The authors' conclusions were as follows:

(A) The adult is susceptible to a derris dust.

(B) The egg is (at any stage of its incubative period) susceptible to nicotine and soap--a fact of vast importance in commercial spray practice.

(C) The newley hatched larva appears to be equally susceptible to nicotine and to derris (each with soap) at the concentrations used, but in the case of nicotine (applied a week after petal fall) it is difficult to differentiate exactly between an effect on the egg and an effect on the larva. Arsenate of lead and barium silicofluoride (each with gelatine) were of about equal value at the concentrations used, and were each much less efficient than nicotine.

(D) The migrating larva. Secondary infestation by migrating larvae, an important phase of sawfly attack, was arrested by a derris dust, by derris and soap, and by nicotine and soap, each applied eighteen days after petal fall.

The same authors observed that migrating larvae of the apple sawfly were controlled best by derris dust (0.19 percent rotenone). Derris-soap reduced the secondary attack but was less effective than the dust.

M. H. Moore, of the East Malling Research Station (25), in 1934 reported field tests of combined derris-fungicide sprays. Derris containing 2.7 percent of rotenone was sprayed on Cox's Orange Pippin apple trees at the rate of 2 pounds per 100 imperial gallons admixed with lime-sulfur and sulfite-lye liquid concentrate (sp. gr. 1.3). The derris program was as follows:

At green-bud	Derris (2 pounds) + sulfite-lye (6 pints)
At pink-bud	Lime-sulfur (1:40) + derris (2 pounds) + sulfite-lye (6 pints)
At petal fall	Lime-sulfur (6 pints) + derris (2 pounds) + sulfite-lye (6 pints)
Three weeks after petal fall	Lime-sulfur (1 gallon)

The conclusions were as follows:

Excellent control of apple scab (Venturia inaequalis Aderh.), red spider (Oligonychus ulmi Koch.) and sawfly (Hoplocampa testudinea Klug.) was given on Cox's Orange Pippin in 1933 by employing a programme of sprays in which lime-sulphur was used in combination with nicotine, with sulphite-lye as wetter and spreader. Reasons are given to show that the effect of the nicotine against sawfly was ovicidal. Where derris was the contact insecticide used, the effectiveness of the combined spray against Sawfly was reduced by about one-half, while against Scab it remained excellent. Lead arsenate was not included in the programme ***.

The East Malling Research Station (26) in 1935 reported dusting and spraying tests against the apple sawfly with derris (2 pounds) + lime-sulfur (6 pints) + sulfonated Lorol (0.5 pound) per 100 imperial gallons, and with nicotine (8 ounces per 100 gallons) sprays. On the Worcesters, nicotine, lime-sulfur, and a wetter reduced the attack by about 85 percent, whereas derris reduced it by only 60 percent, a result which agrees well with last season's findings. It was concluded that derris can considerably reduce sawfly damage but is inferior to a petal-fall application of nicotine, and that a derris dust can control the migratory larvae and so prevent most of the secondary damage.

The Bristol University Agricultural and Horticultural Research Station at Long Ashton, England (11), in 1936 reported that laboratory and field experiments were carried out in 1934-35 with rotenone sprays for the control of the apple sawfly. Investigations showed that nicotine did not act as an ovicide but as a stomach poison to the young larvae. Rotenone also functioned in a similar manner.

Kearns et al. (62) in 1936 concluded that in the control of the apple sawfly rotenone at 1.2 ounces per 100 gallons and derris root at 2.5 pounds per 100 gallons, as constituents of combined sprays of lime-sulfur plus a wetter, proved practically as effective as nicotine at 8 ounces per 100 gallons. When applied up to 8 days before egg hatch, nicotine and derris controlled the apple sawfly by acting as stomach poisons. There was no evidence that nicotine acted as an ovicide.

Steer (110) in 1936 reported that derris was useful as an ingredient of the petal-fall spray for scab. Derris was effective against larvae of the apple sawfly but not against the eggs. Where a petal-fall spray has been omitted, derris dust can be usefully employed to prevent attack by migrating larvae.

The Bristol University Agricultural and Horticultural Research Station at Long Ashton, England (12), in 1937 stated that a biological method for the evaluation of wetters and spreaders had been perfected. The apple sawfly was used as the test insect. Experiments showed that a white-oil emulsion was superior to water-soluble wetters when used in conjunction with a rotenone-containing substance. Investigations were continued on the chemical and biological evaluation of rotenone-containing materials. The work included experiments with the ground root and extracts of species of Derris and Lonchocarpus.

Kearns, Marsh, and Martin (63) in 1937 reported tests made in England with derris, derris extract, and barbasco (5.6 percent rotenone and 17 percent ether extractives) sprays to test the efficacy of spreaders. Rotenone-containing insecticides were shown to be suitable for use in field trials for comparison of the relative efficiencies of spray supplements as penetrants. The synthetic spreaders Agral 2 and sulfonated lorol, used with rotenone-containing insecticides for the control of the apple sawfly, proved to be more effective at 0.05 percent than sulfite-lye at 0.75 percent, gamma-sulfonates at 0.05 percent being intermediate in efficiency. The most effective spray supplement examined was a refined (grade G) petroleum oil emulsified with sulfite-lye, the superior efficiency of which as a penetrant may have been associated with solubility factors.

According to Etablissements Rotenia, in a letter to R. C. Roark in 1938, this pest on cherry trees was killed by a product containing 12 percent of powdered Lonchocarpus nicou root (of 6 percent rotenone content) and 88 percent of talcum.

Plant Protection Ltd. (100) of Yalding, Kent, England, in 1938 advertised Drymac No. 2 as a derris dust suitable for the control of the apple sawfly.

Kearns and Martin (66, 67) in 1939 described tests to control the apple sawfly in England. The results were as follows:

Insecticide	Spreader	Total fruits	Mean sawfly infestation
		Number	Percent
None	Sulfonated lorol	2,111	65.3
Nicotine	Sulfonated lorol	2,220	16.7
Derris (0.25 percent)	Lorol	3,255	15.9
Derris (0.1 percent)	Sulfonated lorol	2,829	39.8
Barbasco (0.1 percent)	Sulfonated lorol	2,732	23.8
Lonchocarpus extract	Sulfonated lorol	2,822	24.2
Lonchocarpus extract	Agral 2	2,562	23.9
Lonchocarpus extract	Gamma-sulfonates	2,478	34.0
Lonchocarpus extract	Sulfite-lye	2,804	39.2
Lonchocarpus extract	Petroleum-oil emulsion	1,795	6.8
Significant differences ($P = 0.05$)		750	12.72

Rotenone-containing sprays act as stomach poisons to newly hatched larvae of the apple sawfly, but apparently the insecticide is not fixed by the calyx-cup tissue and toxicity decreases each day after application. If the period between application and egg hatch is too long, the initial concentration of rotenone may have decreased to such an extent that the larvae are not killed. Variable results are therefore obtained with derris and similar rotenone-containing materials. Further work may indicate a concentration of rotenone that provides a satisfactory duration of toxicity to cover all normal requirements. The sawfly spray must be applied as a drenching application to wet the flowers thoroughly, ensuring that the spray deposited on the stamens will run into the calyx cup.

Hoplocampa sp.

According to the (Tokyo) Institute of Physical and Chemical Research (55) in 1927, a solution of 1 pound of Neoton in 60 gallons of water exterminates larvae of the pear sawfly if they are on the rind of the fruits in course of transition. If a transition takes place after the solution becomes dry, only 40 percent of such larvae succumb.

Metallus rubi Forbes

Daniel (18) in 1928 reported on the control of the blackberry leaf miner, which is probably a limiting factor in the culture of blackberries in western New York. Derrisol, in a dilution of 1:200, averaged 69 percent control when sprayed upon the larvae, but had no value as an ovicide.

Blennocampa rubi (Harr.), the raspberry sawfly

The Michigan Agricultural Experiment Station (87) in 1931 reported that one application of Derrisol at 1:800 plus 2 pounds of Ivory soap per 100 gallons of solution completely controlled the raspberry sawfly, (Monophadnoides) Blennocampa rubi, in a field of red raspberries.

Hutson (50) in 1934 reported that after the fruit was set, raspberry sawfly larvae can be combated with sprays of the contact insecticides, derris or pyrethrum. Derris acts slowly but insects do not feed after they have been hit.

Dutton, Hutson, and Cation (22) in 1936 recommended derris for control of late infestations of sawflies on raspberries. Derris preparations are slow-acting poisons and a good thorough application is required. Repeat in a week if all the larvae are not killed the first time.

Caffrey (15) in 1938 recommended a derris dust containing 0.75 percent of rotenone for the control of the raspberry sawfly on raspberries and blackberries after blooms appear on the plants.

Neurotoma nemoralis (L.)

Jahnke and Roesler (56) in 1940 reported that dust residues of derris retain their effectiveness much longer than those based on pyrethrum or nicotine.

Phymatocera aterrima (Klug)

See Fryer et al. (31) under Pteronidea ribesii (Scop.), on page 22.

Priophorus rubivorus Roh.

Hanson and Webster (42) in 1938 recommended derris or cube dust (0.5 percent rotenone) or spray (0.01 percent rotenone) for the control of the raspberry sawfly.

Pristiphora abietinus (Christ.) (Syn., Lygaeonematus pini Retz.)

DeBussy et al. (14) in 1936 reported that a heavy infestation of larvae of (Lygaeonematus) Pristiphora abietinus in spruce trees was killed in a few hours with a dust containing 0.5 percent of rotenone and 1.2 percent of ether extract. As a result of these experiments, the forester was able to control the infestation by dusting with motor-driven dusting equipment using a dusting mixture containing 0.2 percent of rotenone purchased on the open market.

The Koloniaal Instituut of Amsterdam (76) in 1936 reported that in the Netherlands derris had been used for the control of this species.

Van der Laan (78) in 1936 reported control with derris dust applied by a power duster.

In 1936 Nageli (90) reported having dusted infested spruce trees with Pirox, a rotenone preparation which also contains fungicidal substances and which is prepared by the firm of Dr. Maag in Dielsdorf. Ten to 12 kilograms of Pirox per hectare was used. This treatment completely destroyed the larvae and also, with correctly timed dusting, greatly reduced the damage during the current year.

Lygaeonematus erichsonii (Htg.), the larch sawfly

Kelsall et al. (71) in 1926 reported that an undiluted derris dust, applied with a hand duster, gave 100 percent control of larch sawfly larvae, (Pristiphora) Lygaeonematus erichsonii.

McDaniel (84) in 1939 recommended a dust containing 0.75 percent of rotenone, although about 72 hours were necessary to obtain any indication of kill. Cryolite and calcium arsenate dusts were more effective.

Pteronidea ribesii (Scop.), the imported currant worm

Fryer et al. (31) in 1923 reported an investigation in which extracts of Derris elliptica were shown to have a high insecticidal value, particularly for caterpillars, but were not so toxic to aphids. The dry root itself may be used in a finely powdered condition worked up with water together with soap or other emulsifying reagents. As the pure poisons found in derris root are solids and only slightly soluble in water, their toxicity appears to depend on the degree of dispersion. A biological method of determining insecticidal properties quantitatively is described. It depends on dipping insects, for a constant period of time (10 seconds) in known strengths of highly dispersed suspensoids in dilute aqueous solutions of saponin. Results agreeing with those given by the chemical method already described were obtained. It enabled the authors to compare extracts of derris with nicotine. To certain caterpillars, tubatoxin and derrid were shown to be of the same order of toxicity as nicotine. These conclusions are based on tests with the gooseberry sawfly larvae and larvae of another sawfly, Phymatocera aterrima (Klug).

Durham (21) in 1926 gave an interesting account of his early work with derris, which he regarded as essentially a stomach poison. A fairly large-scale trial was made in June 1904 in a garden at Shelford, where the gooseberries were covered with sawfly larvae; the larvae were promptly killed; and the cooked fruit caused no unpleasant symptoms.

According to Kelsall et al. (71) in 1926, derris at 0.31 pound per 100 imperial gallons of water killed 100 percent. A dust of 98.75 parts hydrated lime and 1.25 parts derris gave 100 percent control in a heavily infested currant plantation.

Turner (117) in 1932 reported the results of work carried on during 1928-31 with cube extract and with rotenone obtained from cube. Cube extract in 0.5 percent of oil emulsified with a sulfonate emulsifier (cube extract 1:25,000) killed 100 percent of the eggs; the check oil killed 12 percent. Two series of tests of repellents were made on the larvae. In the first series cube extract at the rate of 1:25,000 caused death within 24 hours of 80 percent of the 20 larvae, whereas only 15 percent of the 20 larvae on check twigs died. In the second series all the larvae on the sprayed leaves died within 3 days and 84 percent of the larvae on check leaves died within the same period. The high mortality within a short period indicated some toxic action aside from the repellent effect.

Kearns (59) in 1934 reported that "caterpillars" of the gooseberry sawfly are readily controlled by derris spray.

Wilbaux (122) in 1934 tested extracts of the leaves of 22-year-old Tephrosia vogelii and reported that as a contact insecticide the leaves are about as toxic as nicotine. Larvae of the imported currant worm were very sensitive, even when the material was used without a wetting agent. Variable amounts of acetone extract were added to the water used for spraying. The emulsions were used immediately. The following results were obtained:

Concentration	Acetone content	Larvae observed after -- 24 hours	67 hours
	Percent	On seeds	
1:200	1.00	8 dead, 2 sick	9 dead, 1 moribund
1:500	.40	6 dead, 4 sick	10 dead
1:1,000	.20	6 dead, 4 sick	9 dead, 1 moribund
1:2,000	.10	6 dead, 4 sick	8 dead, 1 moribund, 1 sick
1:4,000	.05	5 dead, 5 sick	6 dead, 2 moribund, 2 sick
		On leaves	
1:200	1.00	10 dead	10 dead
1:500	.40	10 dead	10 dead
1:1,000	.20	8 dead, 2 sick	9 dead, 1 living
1:2,000	.10	5 dead, 2 sick 3 living	7 dead, 3 sick
1:4,000	.05	1 dead, 9 living	5 dead, 3 sick, 2 living

The checks sprayed with 1 percent of acetone were unaffected.

DeBussy et al. (14)in 1936 reported that this species is sensitive to derris dust.

According to Van der Laan (78) in 1936, this species may be controlled with derris.

The New York State Agricultural Experiment Station (94) in 1936 reported that when stomach insecticides are needed for control of the imported currant worm a rotenone spray or dust may be used. Studies made in 1935 showed that derris or cube dusts containing from 0.3 to 0.5 percent of rotenone were very effective.

Kearns and Marsh (60) in 1937 recommended a spray containing derris, 1/2 pound of a wetter, and 1 gallon of lime-sulfur per 100 gallons of water for control of gooseberry sawfly and American mildew.

Kearns and Umpleby (69) in 1937 recommended derris for the control of the gooseberry sawfly. The derris dust must be used at a concentration that represents not less than 0.18 percent of crystalline rotenone. A derris, nicotine, or lead arsenate spray may be substituted for the dust.

Kelsall and Stultz (72) in 1937 reported that in laboratory experiments derris-gypsum dusts gave the following results:

Derris in dust Percent	Mortality Percent
0.25	70 in 3 days
.50	70 in 3 days
1.00	90 in 3 days
2.50	91 in 3 days
5.00	100 in 2 days
12.50	100 in 2 days

In field experiments derris was most extraordinarily effective against this insect. Derris used at a concentration of 2.5 percent of rotenone was effective from a practical standpoint. It was observed that bushes treated with derris prevented reinfestation for apparently 3 weeks, whereas bushes treated with pyrethrum were rapidly reinfested by newly hatched insects. From these experiments it is obvious that derris is exceedingly toxic to this insect, but that pyrethrum is toxic only when used copiously.

The New York Agricultural Experiment Station (95) in 1937 reported that the imported currant worm is readily controlled with rotenone sprays and dusts. As infestations of this insect in a given planting are often localized, spot dusting or spraying may be practiced to advantage. All the currant pests for which arsenicals have been used previously may now be controlled by rotenone sprays or dusts, on the use of which there are no legal restrictions.

Hamilton (41) in 1938 reported that currant worms on currant bushes were controlled 100 percent by a spray of derris or cube powder (4 percent rotenone) at 4 pounds per 100 gallons of water plus 4 pounds of rosin-residue emulsion. The spray acted as a contact poison, and killed 100 percent in 1 or 2 days.

Flint and Anderson (30) of the Illinois Agricultural Experiment Station in 1939 recommended a rotenone spray (8 pounds ground derris or cube, containing 0.75 percent rotenone, in 100 gallons of water) for the control of the currant worm on currants and gooseberries. This spray should be applied eerly in the season just after the plants come into full foliage.

Pteronidea salicis (L.)

DeBussy et al. (14) in 1936 reported that this species was sensitive to derris dust.

Selandria atra (Steph.)

According to Etablissements Rotenia in a letter to R. C. Roark in 1938, this pest on pear trees was killed by a product containing 12 percent of powdered Lonchocarpus nicou root (6 percent rotenone) and 88 percent of talcum.

Tomostethus juncivorus Roh.

Harukawa (43) in 1925 reported tests made in Japan with "tuba-fluid," a whitish solution made from derris roots supplied by an insecticide dealer. It was particularly effective against the larvae of the rush sawfly, killing 100 percent when diluted 1:1,000. The addition of soap did not increase the effectiveness.

The Institute of Physical and Chemical Research (55) Tokyo, Japan, in 1927 reported that Neoton at 225 gm. plus 450 gm. of soap per 40 imperial gallons of water gave 85 percent mortality of larvae.

Tenthredinidae (unidentified species)

Tattersfield and Roach (113) in 1923 published some of the results of Durham's work with derris from 1902 to 1907. He found the larvae of sawflies to be very susceptible.

McIndoo and Sievers (85) in 1924 stated that the cold alcoholic extract of cube used with soap was efficient against sawfly larvae. The alcoholic extract of derris used with soap was efficient against half-grown sawfly larvae.

The Institute of Physical and Chemical Research (55) Tokyo, Japan, in 1927 reported that Neoton at 1/2 pound plus 1 pound of soap per 40 imperial gallons of water gave 100 percent mortality.

Hus (49) in 1933 stated that derris preparations could be used for the control of hymenopterous larvae on currants, raspberries, and strawberries.

Hutson (51, 52) in 1936 and again in 1937 wrote that currant worms were controlled by the application of a dust containing 0.5 to 0.75 percent of rotenone at the rate of 15 to 25 pounds per acre. Derris spray was also effective.

According to the Koloniaal Instituut of Amsterdam (75) in 1936, the larvae of sawflies can be destroyed with the help of derris.

The New York (Cornell) Agricultural Experiment Station (92) in 1936 reported that in two counties where currant growing is an important business, considerable difficulty had been experienced in 1934 from arsenical residue. A part of the residue came from spraying the currants for worms, and a part came from the drip from overhanging apple trees. For currants grown in the open, the problem was solved by using a rotenone dust. Where the currants were grown under trees, it was necessary to wash the crop before it could be marketed.

The Illinois Agricultural Experiment Station (54) in 1937 issued directions for spraying fruits in Illinois. The currant worm on currants and gooseberries may be controlled by spraying with 8 pounds of ground derris or cube (0.75 percent rotenone) in 100 gallons of water. Do not wait until the worms appear, but spray early in the season just after the plants come into full foliage.

Westcott, in the New York Times, Sunday, June 6, 1937, wrote that rose slugs (3 species of sawfly larvae) are readily controlled by a combination spray or dust containing lead arsenate or rotenone.

According to the New Jersey Agricultural Experiment Station (91) in 1938, derris or cube powder in water to which rosin-residue emulsion had been added was effective against sawfly larvae. June sawfly larvae and currant worms were easily killed.

Parks and Pierstorff (97) in 1938 recommended the application of a derris or cube dust (0.5 percent of rotenone) or spray (3 pounds of powder containing 4 percent of rotenone in 100 gallons of water) for the control of currant worms on currant.

C. B. Dibble, of Michigan, in a "Bug Flash" in 1940, recommended derris or cube dusts diluted with flour or talc, or commercial dusts containing 0.5 or 0.75 percent of rotenone for the control of the raspberry sawfly.

Fenne (28) in 1940 recommended derris and cube dusts and sprays for control of currant worms.

Vespidae (unidentified sp.)

An anonymous writer (1) in 1927 reported that a large hornet in flight was stunned, and later died, when sprayed with a proprietary derris product probably Neoton at the rate of 100 gm. in 300 liters of water.

Downes (20) in 1939 reported that a hornet's nest in a cherry tree was destroyed in 24 hours by throwing a handful of derris powder (4 percent rotenone) at the hole in the side of the nest.

Unidentified species of Hymenoptera

Geoffroy (32) in 1895 reported that sugar dipped in a saturated alcoholic solution of rotenone and dried in an oven was highly toxic to wasps.

The Wageningen Plantenziektenkundige Dienst (120) in 1934 reported that rotenone 1:5,000 with the addition of 0.1 percent of Agral I was satisfactory against hymenopterous larvae on Astilbe at Amsterdam.

DeBussy et al. (14) in 1936 reported that leaf-wasp larvae are very sensitive to derris.

Van der Laan (78) in 1936 reported that wasps are less sensitive than honeybees to derris.

Downes (20) in 1939 stated that a small wasps' nest was destroyed within 5 hours with derris powder (4 percent rotenone).

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